MASTER OF SCIENCE
IN
APPLIED PHYSICS

EXPERIMENTAL STUDIES OF APPLICATIONS OF TIME–REVERSAL ACOUSTICS TO NON-COHERENT UNDERWATER COMMUNICATIONS

Michael Gerhard Heinemann-Kapitänleutnant, German Navy
Diploma, University of German Armed Forces, Munich, 1992
Master of Science in Applied Physics-March 2000
Master of Science in Engineering Acoustics-March 2000
Advisors: Andrés Larraza, Department of Physics
Kevin B. Smith, Department of Physics

The most difficult problem in shallow underwater acoustic communications is considered to be the time-varying multipath propagation because it impacts negatively on data rates. Computationally intensive and complex signal processing algorithms are required to compensate for symbol overlapping. This thesis presents results of a tank scale experiment to test Time-Reversal Acoustics (TRA) approach for high data rate binary transmissions. TRA can environmentally adapt the acoustic propagation effects of a complex medium. Our results show the suitability of the TRA approach in underwater acoustic communications. The results also show good focusing properties at an intended target location. The focal region extends over a few wavelengths, outside of which scrambling of the message occurs, offering natural encryption. Range shifts of the focal region could be achieved by frequency shifting. We found that the time focusing is aperture–size independent, but the spatial focusing is aperture–size dependent. Overall, we showed that our algorithm can accomplish a fast, secure, and stable communication scheme with low computational complexity.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Time Reversal Acoustics, Acoustic Communications, Acoustic Signal Processing

APPLICATION OF THE ROBUST SYMMETRICAL NUMBER SYSTEM TO HIGH RESOLUTION DIRECTION FINDING INTERFEROMETRY

David J. Wickersham-Lieutenant, United States Navy
B.S., United States Naval Academy, 1992
Master of Science in Applied Physics-March 2000
Advisors: Phillip E. Pace, Department of Electrical and Computer Engineering
D. Scott Davis, Department of Physics

To reduce the number of phase sampling comparators in a direction finding (DF) interferometer antenna, a new array based on a robust symmetrical number system (RSNS) is described. The RSNS is used to decompose the spatial filtering operation into a number of parallel sub-operations that are of smaller computational complexity. Each sub-operation (interferometer) symmetrically folds the phase with folding period equal to $2Nm_i$ where N is the number of channels that are used and m_i is the channel modulus. A small comparator ladder mid-level quantizes each folded phase response. Each sub-operation only requires a precision in accordance with that modulus. A much higher DF resolution is achieved after the N different

RSNS moduli are used and the results of these low precision sub-operations are recombined. The parallel use of phase waveforms increases the antenna resolution without increasing the folding rate of the system. The new antenna is constructed and tested in an anechoic chamber, and the results are compared with the experimental results of a previously tested optimum symmetrical number system (OSNS) array. Although the dynamic range of the RSNS is somewhat less than the OSNS, the inherent Gray code properties make it attractive for error control in phase sampling interferometry.

DoD KEY TECHNOLOGY AREAS: Sensors, Electronic Warfare

KEYWORDS: Robust Symmetrical Number Systems, Optimum Symmetrical Number Systems, Phase Sampling Interferometery, Direction Finding, Ambiguity Resolution